

**COMPOSITION, METHOD, AND APPARATUS FOR PROTECTING PLANTS  
FROM INJURY CAUSED BY FROST OR FREEZING TEMPERATURES**

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**Cross-Reference to Related Application**

This application claims benefit of U.S. Provisional Application Serial No. 60/054,846, filed August 6, 1997 which is directed to a composition and method for protecting plants from injury caused by frost or freezing temperatures.

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**Background of the Invention**

This invention relates to a protecting plants from injury due to frost or freezing and, more particularly, to a composition, method, and apparatus for protecting plants from injury caused by frost or freezing temperatures.

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When plants are exposed to freezing conditions during the growing season, temporary or permanent injury to the plants is likely to occur. Such injury is one of the leading causes of loss in the agricultural industry. It has been estimated that from 5 to 15 percent of the gross world agricultural product is lost to frost damage in one year. According to one estimate, approximately 10 billion dollars of agricultural products are lost annually to plant and crop freezing world-wide each year.

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Frost sensitive plants and fruits generally cannot tolerate ice formation within their tissues and break down and become flacid and discolored as the plant begins to warm. Typically, during a light freeze when temperatures range between -2C to 0C (29F/32F), tender plants are often killed or damage with little effect on other vegetation. During a

moderate freeze when temperatures range between -8C and -2C (25F to 28F), heavy damage will occur to most plants, including fruit blossoms and tender semi-hardy plants. During a severe freeze when temperatures drop below -9C (24F), heavy damage will occur to most plants.

5 Present methods of protecting vegetation from frost include warming the air surrounding the plants using heating devices, such as smudge pots, heat blowers and canopy heaters, placed near the plants; stirring the air over the plants by use of helicopters or air blowing equipment; and covering the plants with a insulating material such as water, fogs, material tarps, and foam sheeting material. Such methods of frost protection, however, are  
10 undesirable due to their tendency to pollute as in the case of heating devices, or are relatively expensive, as in the case of utilizing wind blowing devices or helicopters, or are relatively labor intensive as in the case of utilizing tarps or foam sheeting materials. Further, such frost protection devices often achieve limited success, particularly when the ambient air temperature falls well below freezing for a substantial amount of time or during windy  
15 conditions.

In addition to such physical methods, various chemical methods have been developed and used for reducing or preventing injury to vegetation caused by frost or freezing temperatures. Such methods include applying various chemical compounds onto the plants to be protected to lower the temperature at which plant damage occurs. Such chemical  
20 methods, however, tend to be unreliable, relatively expensive, and ecologically specious.

Accordingly, a need exists for a composition, method, and apparatus of protecting plants from injury caused by frost or freezing temperatures which is relatively inexpensive, environmentally acceptable, non-toxic, ecologically sound, and is not labor intensive.

### **Summary of the Invention**

5           The present invention is directed to a composition and method for producing a relatively stable insulating foam, and a method and apparatus for applying the insulating foam to the surface of plants and crops for effectively hindering or reducing injury to the plants caused by frost or freezing temperatures.

10           In a preferred embodiment of the invention, the composition comprises a vegetable oil, and a foaming agent and/or stabilizer for producing a relatively stable insulating foam.

          In another preferred embodiment of the invention, the composition comprises a vegetable oil, an emulsifier, and a foaming agent to form a pre-emulsion concentrate which can be mixed with water to form an oil-in-water emulsion which is effective for producing a relatively stable insulating foam.

15           In another preferred embodiment of the invention the vegetable oil is selected from the group comprising coconut oil, corn oil, cottonseed oil, palm oil, rapeseed oil, and sunflower oil.

          In another preferred embodiment of the invention the vegetable oil is a soya oil.

          In another preferred embodiment of the invention the vegetable oil is a crude, non-

refined vegetable oil.

In another preferred embodiment of the invention the vegetable oil is a crude, non-refined soya oil.

In another preferred embodiment of the invention, the composition of the present  
5 invention comprises an alkyl alcohol ethoxylate emulsifier.

In another preferred embodiment of the invention, the composition of the present invention comprises a foam stabilizer.

In another preferred embodiment of the invention, the composition of the present invention comprises a thickener.

10 In another preferred embodiment of the invention, the composition of the present invention may be used as a crop adjuvant,

In another preferred embodiment of the invention, the composition of the present invention comprises a plant growth regulator.

In another preferred embodiment of the invention, the composition of the present  
15 invention comprises a pesticide.

In another preferred embodiment of the invention, the foaming agent of the present invention comprises neutralized alkyl sulfate and triethanolamine.

In another preferred embodiment of the invention, the foaming agent of the present invention comprises an amine oxide.

20 In another preferred embodiment of the invention, the foaming agent of the present

invention comprises a quaternary ammonium compound.

In another preferred embodiment of the invention, the foaming agent of the present invention comprises an alkyl <sup>oxyalkylate</sup> ~~alcohol~~.

In another preferred embodiment of the invention, the foaming agent of the present invention comprises an aryl <sup>oxyalkylate</sup> ~~alcohol~~.

In another preferred embodiment of the invention, the foaming agent of the present invention comprises a hydrolyzed protein.

In another preferred embodiment of the invention, the foaming agent of the present invention comprises oxyalkylates.

10 In another preferred embodiment of the invention, the foaming agent of the present invention comprises neutralized alkyl sulfates.

In another preferred embodiment of the invention, the foaming agent of the present invention comprises neutralized alkyl and aryl sulfonates.

15 In another preferred embodiment of the invention, the foam stabilizer of the present invention comprises a carboxyalkylcellulose.

In another preferred embodiment of the invention, the thickener of the present invention comprises a mucilage.

In another preferred embodiment of the invention, the growth regulator of the present invention comprises an ethylene.

20 In another preferred embodiment of the invention, the pesticide of the present

invention comprises malathion.

In another preferred embodiment of the invention, the pesticide of the present invention comprises mineral oil.

In a preferred embodiment of the invention, the composition of the present invention  
5 comprises methylated silica polydimethylsiloxane.

In another preferred embodiment of the invention, the composition of the present invention is stored in a manner whereby the foam concentrate is stored a holding tank in flow communication with a water source.

In another preferred embodiment of the invention, the composition of the present  
10 invention is aerated by a method and apparatus to produce a foam which is sprayed or deposited onto the surface of the plant to be protected to form an insulating foam layer or blanket.

In another preferred embodiment of the invention, the method and apparatus to aerate the composition of the present invention is by means of a nozzle having means for  
15 inducing air into the composition.

In another preferred embodiment of the invention, the composition is deposited onto plants by means of a pressurized container.

A primary object of this invention, therefore, is to provide a composition, method and apparatus of preventing or reducing injury to plants caused by frost or freezing  
20 temperatures.

Another primary object of this invention is to provide a pre-emulsion concentrate which is stable and does not separate during storage.

Another primary object of this invention is to provide an insulation foam for protecting plants from injury caused by frost or freezing temperatures.

Another primary object of this invention is to provide a composition for protecting plants from injury caused by frost or freezing temperatures which is ecologically acceptable.

Another primary object of this invention is to provide a composition and method of protecting plants from injury caused by frost or freezing temperatures which applies relatively easily and in a relatively short amount of time.

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These and other objects and advantages of the invention will be apparent from the following drawings and detailed description of the preferred embodiments.

**Brief Description of the Drawings**

**FIG. 1** is a schematic representation of a foam dispensing apparatus of the present invention showing a system for spraying and covering plants with the insulating foam of the present invention;

**FIG. 2** is a side view, partially broken, showing in more detail the foam forming nozzle assembly of the foam dispensing apparatus of **FIG. 1**;

**FIG. 3** is a schematic representation of another embodiment of a foam dispensing apparatus of the present invention showing another system for spraying and covering plants with the insulating foam of the present invention comprising additional supply tanks;

**FIG. 4**, is another embodiment of a foam dispensing apparatus of the present invention showing another system for spraying and covering plants with the insulating foam of the present invention having water supplied through a hose and the pre-emulsion concentrate being drawn into the water stream by aspiration or by pressure and discharged as foam through the nozzle; and

**FIG. 5** is another embodiment of a foam dispensing apparatus of the present invention showing another system for spraying and covering plants having a pressurized cylinder having a spray nozzle and containing the foam concentrate of the present invention and a gas propellant.



**Detailed Description of Preferred Embodiments**

*[Handwritten signature: Sun 9/2]*

The present invention for protecting plants from injury caused by frost or freezing temperatures comprises an insulating foam effective for providing a blanket or insulating layer along the surface of the plants to be protected. The insulating foam is produced from a composition comprising a vegetable oil and a foaming agent. Preferably, the vegetable oil comprising the insulating foam is soya oil, however, other suitable vegetable oils include coconut oil, corn oil, cottonseed oil, palm oil, rapeseed oil, and sunflower oil. In addition, the vegetable oil is preferably a crude, non-refined or nonpurified oil. It should now be apparent to one skilled in the art that the use of a crude, non-refined vegetable oil as a base component will be significantly less expensive than using a refined or a purified vegetable oil. Further, crude vegetable oils, especially crude soya oil, contain tocopherol which is a natural antioxidant and functions as a preservative. This permits the foam producing composition to be stored for use without or with the use of significantly less additional preservatives. Crude vegetable oils also contain gums which improve the oil's stickability or adhesion characteristics thereby increasing the ability of the foam to cling to the plant's surfaces. In this way, the composition may also be used as an adjuvant to assist in the adhesion and spreading of growth regulators such as ethylene, and pesticides such as mineral oil and malathion.

*[Handwritten signature: Sun 9/2]*

The insulating foam is produced from a composition comprising an oil and water emulsion prepared from a pre-emulsion concentrate using an emulsifier which is suitable for providing a stable oil and emulsifier composition having a relatively large percentage of

vegetable oil. One problem with producing a foam which is effective for providing protection for a plant from injury caused by frost or freezing temperatures is the difficulty of providing a stable oil and emulsifier composition having a relatively large percentage of vegetable oil. This is particularly true for compositions comprising crude, non-refined vegetable oils. Emulsifiers which have been found to be particularly suitable include alkyl, aryl or glycol ethoxylate, propoxylate, butoxylate or sulfonate-based emulsifiers.

One emulsifier which has been found to be particularly effective for producing a stable pre-emulsion concentrate comprising crude, nonpurified or nonrefined soya oil comprises a 3 mole ethylene oxide adduct of C12 and C14 alcohols. In formulating the emulsifier, about 30% to about 50% by weight of C12 alcohol is first mixed with about 50% to about 70% C14 alcohol. The C12 and C14 alcohols are then ethoxylated with 3 moles of ethylene oxide to produce the desired emulsifier.

In another preferred embodiment of the invention, it was unexpectedly found that the use of a silicone compound typically used for food systems, such as a methylated silica polydimethylsiloxane, such as sold by Dow Corning under the name Anti Foam 1500, may be used to produce a stable and relatively tight foam. Such a composition may be particularly suited for use for providing an insulating foam utilizing a pressurized container or a container using a propellant such as an inert gas or air.

Suitable foaming agents such as quaternary ammonium compounds, amine oxides, neutralized alkyl sulfates, neutralized alkyl and aryl sulfonates, hydrolyzed protein, alkyl and aryl alcohols, and oxyalkylates may be used in the composition of the present invention.

Foam thickeners and stabilizers such as carboxyalkylcellulose and mucilage may also be used in the composition. Emulsifying agents may be used as foam thickeners and foam stabilizers and may also be used as emulsifiers to produce a stable pre-emulsion concentrate for storage purposes as well as to produce a stable foam.

- 5           In a preferred embodiment of the present invention, the composition effective for producing a stable foam concentrate is prepared by mixing about 40% to about 90% by weight of a crude, nonpurified or nonrefined vegetable oil with about 1% to about 40% by weight of an emulsifier, and about 0.5% to about 10% sodium lauryl sulfate and about 0.5% to about 10% triethanolamine. The composition may be stored until ready to use or shipped
- 10   to the ultimate customer for use.

In order to further illustrate the invention, the following specific example of a composition for preventing or hindering injury to plants caused by frost or freezing temperatures were prepared:

#### EXAMPLE 1

- 15           A composition for preventing or hindering injury to plants caused by frost or freezing temperatures was prepared by mixing together by agitation a crude, nonpurified or nonrefined soya oil with an emulsifier comprising a 3 mole ethylene oxide adduct of C12 and C14 alcohols in a 500 gallon mixing vessel. The following quantities were used to produce the desired composition resulting in a stable and relatively tight insulating foam:

<u>Material</u>	<u>Volume (gal)</u>	<u>Vol (%)</u>	<u>Weight (lbs)</u>	<u>Wt (%)</u>
Crude soya oil	400.0	85.0	3120.0	85.2
Emulsifier	71.0	15.0	543.2	14.8
	_____	_____	_____	_____
	471.0	100.0	3663.2	100.0

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Agitation was provided by a 3.5 Horsepower pump. The composition was pulled from the bottom of the mixing vessel, sheared and moved by the pump through a 1.5 inch diameter hose, returned through the top of the vessel to fall back into the composition remaining in the vessel. The emulsifier was added slowly through the top of the vessel over a 30 minute period during agitation. Foam was formed on top of the composition in the vessel and began to accumulate. 15 grams of methylated silica polydimethylsiloxane, sold under the name Antifoam 1500 by the Dow Corning Company was added to the composition and agitation was continued. Unexpectedly, the Antifoam 1500 resulted in a more stable and tighter foam.

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The insulating foam layer or blanket for hindering or preventing injury to plants caused by frost or freezing displayed surprising characteristics. After about ten hours, the foam formed by the composition of the present invention continued to be stable and had not broken. In addition, the foam layer appeared to have caused no detrimental effects to the plants.

**EXAMPLE 2**

A composition for preventing or hindering injury to plants caused by frost or freezing temperatures was prepared by mixing together by agitation a crude, nonpurified or nonrefined soya oil with an emulsifier comprising a 3 mole ethylene oxide adduct of C12 and C14 alcohols. The following ratio was used for quantities to produce the desired pre-emulsion concentrate:

	<u><b>Material</b></u>	<u><b>Weight (%)</b></u>
	Crude soy oil	75.0
	Emulsifier	20.0
10	Sodium Lauryl Sulfate	3.0
	Triethanolamine	2.0

Agitation was provided by a lab blender (3200 rpm) at 35 degrees C to produce 200 grams of the concentrate.. The pre-emulsion concentrate was then mixed with water to produce 3% and 9% solutions which were pumped through a aerating nozzle to produce a relatively stable and tight foam. The foam was then applied to leaves of a young tomato plant to produce an insulating layer or blanket. After five hours the foam remained relatively stable and appeared to produce no harmful effects to the tomato plant.

As previously described, the composition of the present invention comprises a relatively inexpensive, environmentally acceptable, non-toxic, and ecologically sound foam which is effective for hindering or preventing plants from injury caused by frost or freezing temperatures.

Referring to **FIG. 1**, a schematic representation of a preferred embodiment of a foam dispensing apparatus, generally designated **100**, of the present invention is shown illustrating a foam dispensing system for spraying and covering plants with a blanket of insulating foam. The foam dispensing apparatus **100** comprises a pre-emulsion concentrate storage tank **102** having an outlet **104**, and a water supply **106** having an outlet **108**. The storage tank **102** and a conventional water supply **106** are both in fluid communication with a foam forming nozzle assembly **110** through a system of conduits, generally designated **112**. In operation, the pre-emulsion concentrate of the invention is directed out of the outlet **104** of the pre-emulsion concentrate storage tank **102** and through conduit **114** to a mixer **116**. Water, which has been directed to the mixer **116** from the water supply **106** through outlet **108** and conduit **118**, is mixed with the pre-emulsion concentrate to form an oil and water emulsion. A fluid pump **120**, powered by a conventional electric or gasoline powered motor **122**, is provided to pump the oil and water emulsion to the foam forming nozzle assembly **110**. It should be apparent to one skilled in the art that the pump **120** must provide sufficient pressure to blow and produced a foam spray **F** which can be directed onto the plants to be protected. It should also now be apparent that the required pressure is dependent on the number and size of the nozzles, the distance to blow, the length and diameter of the conduits, the coverage necessary, and the concentration of the oil and water emulsion. The pressure necessary for any particular application may be easily determined by one skilled in the art.

The pump **120** includes an inlet **124** connected to the mixer **116** through conduit **126**

and an outlet **128** which is connected to the foam forming nozzle assembly **110** through conduit **130**. The outlet **104** of the pre-emulsion concentrate storage tank **102** and the outlet **108** of the water supply **106** are each provided with a valves **132** and **134**, respectively, for adjusting the amount of water and pre-emulsion concentrate entering the  
5 mixer **116**. By adjusting the oil and water emulsion, the density of the foam can be regulated to meet the specific insulating need of the crop or plant. For example, by increasing or decreasing the ratio of the pre-emulsion concentrate and water, the density of the foam can be increased or decreased.

The foam forming nozzle assembly **110** for producing and spraying a foam whereby  
10 plants may be covered with an insulating blanket of foam is designed to inject or draw air into the oil and water emulsion and to direct the foam spray to the area of the plants and crops to be protected. Depending on the application, the foam forming nozzle assembly **110** may also be conventionally designed to atomize the oil and water emulsion to improve aspiration. Referring to **FIG. 2**, a preferred embodiment of a foam forming nozzle assembly  
15 **110** is illustrated comprising a cylindrical member **136** having an inlet **138** for receiving the oil and water emulsion through conduit **130** and an outlet **140** for discharging a foam spray **F**. The cylindrical member **136** is provided with a plurality of lateral air inlets **142** through which air is drawn into the oil and water emulsion stream **S** to form the insulating foam spray **F**.

20 It should be apparent to one skilled in the art that other foam dispensing apparatus using various systems may be used to form and distribute the foam of this invention across

the surfaces of plants. While the foam dispensing apparatus disclosed herein illustrate and describe specific systems which may be utilized to dispense and apply foam to plants, the disclosure of such foam dispensing apparatus and systems is only an exemplification of the principals for applying a foam blanket on plants and is not intended to limit the invention to the particular foam dispensing apparatus or systems illustrated and described. For example, foam dispensing apparatus may be conventionally designed for a system which is placed within the bed of a truck or a trailer to be transported through a field. In addition, as shown in **FIG. 3**, the foam dispensing apparatus may include additional tanks 144 containing various types of chemicals, including herbicides, fungicides, fertilizers, insecticides and the like, to permit the foam produced by this invention to operate as a carrier. It has been found that the tacky nature of the foam produced by this invention has shown the foam to be an excellent crop adjuvant to assist in the adhesion and spreading of growth regulators and/or pesticides. Hand held systems having foam dispensing apparatus, such as shown in **FIG. 4**, may include hose-end dispenser devices whereby water is supplied through a hose 146 and the pre-emulsion concentrate is drawn from a holding container 148 into the water stream S through a hose 150 by aspiration or by pressure and mixed with the water stream S and discharged as foam through the nozzle 152. Another foam dispensing apparatus is shown in **FIG. 5** comprising a pressurized cylinder 154 and a spray nozzle 156. Contained within the pressurized cylinder 154 is the foam concentrate of the present invention 158, such as previously shown in Example 1, and a gas propellant 160 for expelling the concentrate out through conduit 162 and spray nozzle 156 which



forms the insulating foam F.

It should also now be apparent to one skilled in the art that the systems using foam producing apparatus, such as previously described, may include the use of a plurality of foam producing nozzles or require such nozzles to be mounted on various devices such as  
5 poles, booms, elongated manifolds and the like to permit effective plant coverage.

It should also now be apparent to one skilled in the art that the foam dispensing apparatus can easily be incorporated into existing or conventional crop spraying systems which are supplied with or may be equipped with air aspiration nozzles.

There has thus been provided a novel composition and method for producing a  
10 relatively stable insulating foam and an apparatus and a method of applying the insulating foam to the surface of plants and crops for effectively hindering or reducing injury to plants and crops caused by frost or freezing temperatures. The composition of the present invention is relatively inexpensive, environmentally acceptable, ecologically sound, nontoxic, and should have no detrimental effects on plant life or development. In fact, it has been  
15 found that the use of the vegetable oil of the present invention operates effectively as a pesticide to reduce insect damage. It has also been found that the tacky nature of the foam produced by this invention allows the foam to be used as a crop adjuvant.

Although this invention has been shown and described with respect to detailed embodiments thereof, it will be understood by those skilled in the art that various changes  
20 in form and detail thereof may be made without departing from the basic principles, spirit, and scope of the claimed invention.

We claim: